



SP2014_2925788 GREEN PROPULSION AUXILIARY POWER UNIT DEMONSTRATION AT MSFC

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Outline

1. Beginning of MSFC involvement (NEPP)
 2. Discussion of TA-01 Roadmap
 3. Green Propellant TDM
 4. Status of MSFC APU work
 5. Conclusion
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- Companion paper to SP2014_2969495
 - Green Mono Propulsion Activities at MSFC

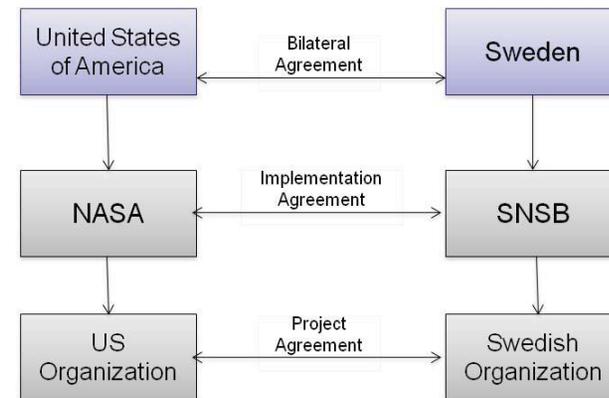
Nanoenergetics Propulsion Project

- Starting in April 2010, the Office of Chief Technologist began the Nanoenergetics Propulsion Project (NEPP).
 - Nanoenergetics, such as aluminum, offer benefits in combustion systems such as lower ignition temperatures and increased reactivity.
- Became Project Manager in Jan 2011 to oversee NEPP.
 - Partnered with Naval Surface Warfare Center, Air Force Office of Scientific Research, Purdue and Penn State Universities.
- During the annual Technology Assessment Working Group meeting in June 2011, there were 2 dozen candidates considered with ammonium dinitramide (ADN) being in the top 3.
- Throughout the spring/summer of 2011, MSFC was visited by ATK, ECAPS, and SNSB regarding use of ADN in the green propellant LMP-103S.
- Unfortunately, NEPP was cancelled at the end of FY12.
 - However, the spark was started for MSFC to pursue green propellants.
 - This led to MSFC discussions with Goddard Space Flight Center and the Jet Propulsion Laboratory about future spacecraft propulsion opportunities as well as site visits to Vandenberg Air Force Base and the Kennedy Space Center for coordination with launch personnel.

Trip to ECAPS, FOI, and Eurenco (Sept 2011)

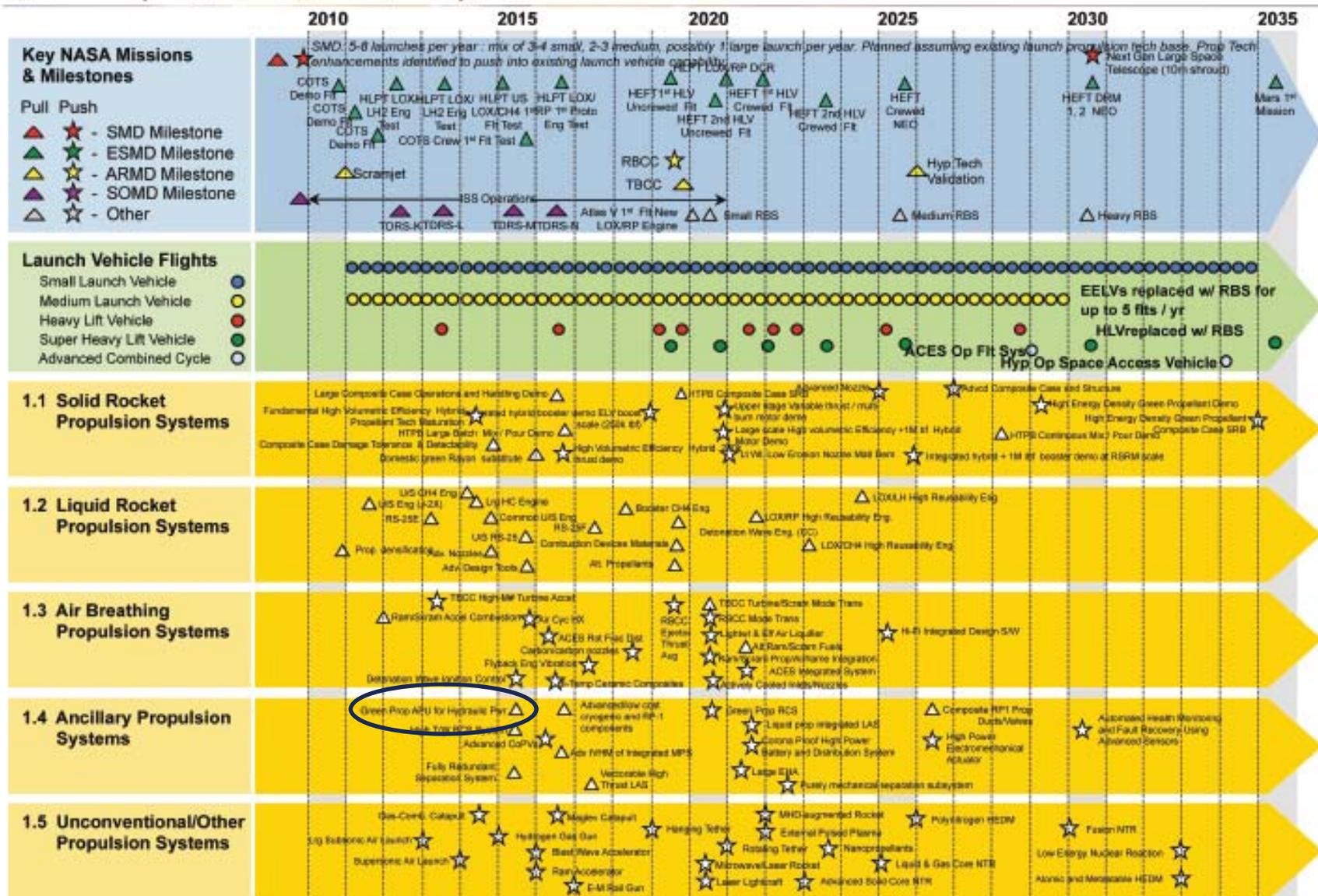


Bilateral space agreement between USA and Sweden



TA-01 Launch Propulsion System Roadmap

Figure 1: Launch Propulsion Systems Technology Area Strategic Roadmap (TASR).



NASA TDM Solicitation

- MSFC led a Technical Interchange Meeting focused on LMP-103S at KSC the last week of January 2012.
 - The green propellant focused TDM12 synopsis was released on Jan 18th.
 - Serendipitously, this allowed the various Centers to discuss how to team together.
- Solicitation was focused on hydrazine replacement with max award of \$50M.
 - TDM was interested in selecting projects that provide a balanced program portfolio that includes **lower**, mid-range and higher cost demonstrations.
 - Demonstrations would be relevant to in-space RCS, in-space primary propulsion, launch vehicle RCS and **launch vehicle power generation**.
 - Relevant environments for demonstrations include **ground**, aerial, suborbital or orbital regimes.
- It was speculated that IF the TDM budget is capped at \$50M, then TDM may award a \$5M, \$15M and \$30M proposals.
- Objective - Demonstrate application of LMP-103S to APU systems while minimizing design changes to existing APU hardware.
 - Early batch testing followed by testing in gas generator test bed.
 - Risk reduction by using F-16 Emergency Power Unit at MSFC CDA (B4656).
 - Continued testing of gas generator asset culminating in final demonstration in APU system.
- Highest risk is current decomposition temperature of propellant.
 - Risk reduction planned for this proposal is to a) dilute the propellant, b) reduce residence time of catalyst and c) dilute post decomposition.

Plan

(2) F-16A EPU's



Phase 1 Feasibility Testing

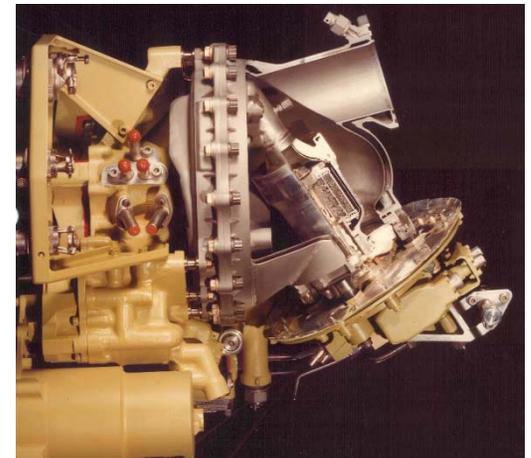
Phase 12 Gas Generator Testing

SRB GG5116



Phase 3 System Testing

Orbiter APU Engineering Test Unit S/N-008



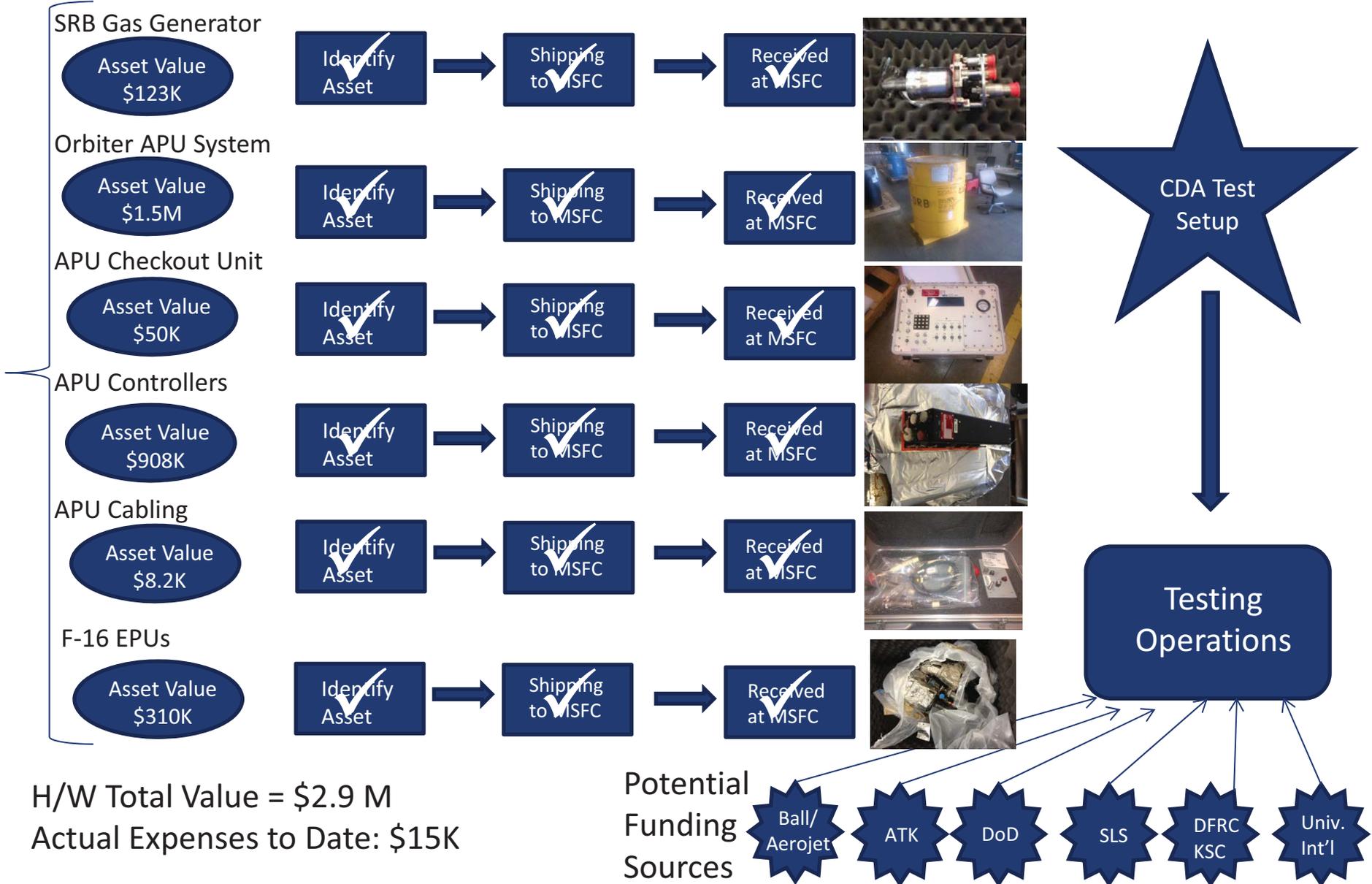
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Additional hardware being excessed from SLS Core Stage:

- 9 gas generators
- 2 gas generator valve modules

Accumulation of Test Hardware

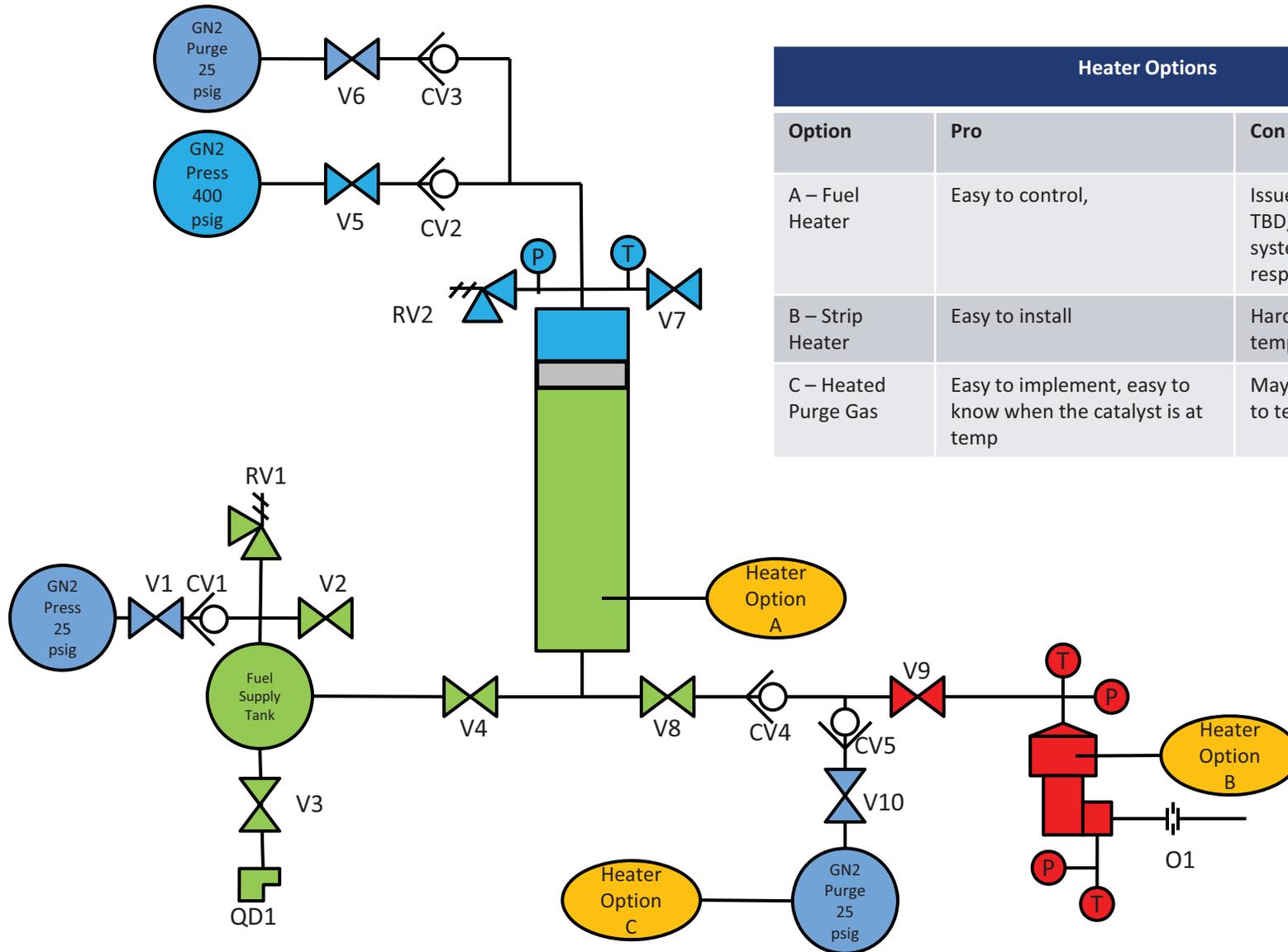


Status of Phase 1

- MSFC received key drawings, operations manuals and acceptance test procedures for the F-16 EPU.
- In collaboration with AFRL, we are working on reactivity of Hydroxyl Ammonium Nitrate (HAN) based propellants for use in power generation.
- MSFC has removed a gas generator (GG) from one assembly and are preparing to test.
- Based on the EPU GG testing, we will reinstall into assembly for additional testing.
- MSFC has arranged a demo at Edwards Air Force Base in the Aug/Sept timeframe.



General Layout



Heater Options		
Option	Pro	Con
A – Fuel Heater	Easy to control,	Issues with reaction are TBD, May require a bleed system, potentially slow response.
B – Strip Heater	Easy to install	Hard to tell the catalyst temperature
C – Heated Purge Gas	Easy to implement, easy to know when the catalyst is at temp	May take the longest to get to temp.

Conclusions

- MSFC has embarked on use of green propellant replacement of hydrazine for a variety of applications.
- This paper focused on activities for auxiliary power unit but MSFC is actively investigating use of green propellants for thruster applications.
- MSFC is interested in partnership with the international community to address the infusion of green propellant into greater use.